The A Dependence of Open Charm and Bottom Production*

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Previously, the heavy quark production cross section was calculated in pp interactions focussing on the scale dependence and fixing the mass and scale as parameters in the total cross section [1]. In this extension to pA and AA interactions, we study the effects of shadowing and p_T broadening on heavy quark production.

The average intrinsic k_T is expected to increase in pA interactions. This broadening is observed in Drell-Yan, J/ψ, and Υ production and has been used to explain high p_T pion production in nuclear interactions. Since k_T broadening has not been explicitly measured in charm production, we assume that the k_T broadening arises from multiple scattering of the projectile partons in the target,

$$\langle k_T^2 \rangle_A = \langle k_T^2 \rangle_p + (\langle \nu \rangle - 1)\Delta^2(\mu) \ . \tag{1}$$

Shadowing is an area of intense study with numerous models available in the literature. However, none of the models can satisfactorily explain the behavior of the nuclear parton distributions over the entire x and μ^2 range. Therefore, we choose to use parameterizations of shadowing based on nuclear DIS data. We use the recent EKS98 parameterization [2] based on the GRV LO parton densities in the proton.

We show inclusive charm and bottom and exclusive $c\overline{c}$ and $b\overline{b}$ production at several different energies. First we show fixed target charm production at 158, 450, and 800 GeV. These energies are chosen because Pb+Pb interactions are studied at the CERN SPS at 158 GeV/nucleon and it would be useful to examine charm production in pp and pPb interactions at the same energy. However, since this would require a secondary beam, we also show the results at the SPS primary proton beam energy of 450 GeV. The Fermilab fixed target program has an 800 GeV beam which could also be used for studies of the charm A dependence. Indeed, a great many experiments have studied charm production, both at CERN and at Fermilab but unfortunately the statistics for proton beams have generally been poor and the results have not been used to determine the A dependence. Better statistics are available for π beams but the data is typically averaged over all targets to enhance statistics rather than to study the A dependence. Since the RHIC and LHC heavy ion programs will include pA studies, we also show results at the complementary ion-ion energy, $\sqrt{s} = 200$ GeV/nucleon and 5.5 TeV/nucleon, respectively.

All the pp calculations are shown with $\langle k_T^2 \rangle = 1$ GeV^2 and all the pA calculations are presented with $\langle k_T^2 \rangle = 1.35$ GeV^2 for charm and 2.57 GeV^2 for bottom. In AA collisions, the broadening is increased by a factor of two for the second nucleus, giving $\langle k_T^2 \rangle = 1.7$ GeV^2 for charm and 3.14 GeV^2 for bottom. The pA and AA calculations are modified by spatially homogeneous shadowing with the EKS98 parameterization.

The $Q\overline{Q}$ p_T, the single quark p_T and the pair ϕ distribution are most sensitive to the effects of k_T broadening while the pair and single quark rapidities are sensitive to shadowing. There is significantly less distortion of the nuclear effects in the pair distributions which are the most difficult to measure. The same results may be obtained through measurements of the single heavy quarks event though the definitions of x and k_T are smeared relative to those of the pair.

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